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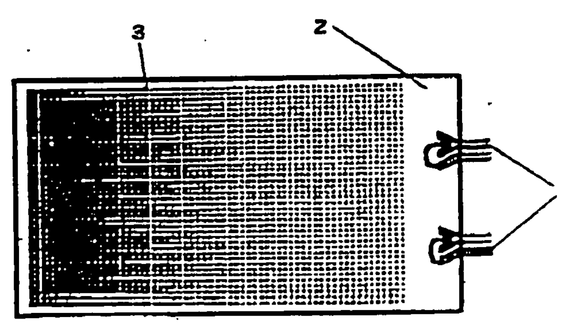
(54)【発明の名称】　面状光源

(57)【要約】
【目的】　青色発光ダイオードを用いた白色可能な面状光源を実現し、均一な白色発光を観測できる面状光源を提供する。
【構成】　透明な導光板の端面に発光ダイオードが光学的に接続されており、さらに前記導光板の主面のいずれか一方に、前記青色発光ダイオードの発光により励起されて蛍光を発する蛍光物質と、蛍光を散乱させる白色粉末とが混合された状態で塗布された蛍光散乱層を有し、前記青色発光ダイオードの発光が前記蛍光散乱層で波長変換される。

具体的材料の商品名記載あり。



(7-176794)

(54) [TITLE OF THE INVENTION] PLANAR LIGHT SOURCE

(57) [ABSTRACT]

[Purpose] To realize a planar light source using a blue light-emitting diode and being capable of allowing white color and to provide a planar light source capable of allowing observation of uniform white color light emission.

[Construction] A light-emitting diode is optically connected to an end surface of a transparent optical guiding plate, and either one of the principal surfaces of said optical guiding plate includes a fluorescent scattering layer in which a fluorescent substance emitting a fluorescence by being excited with the light emission of said blue light-emitting diode and a white powder scattering the fluorescence are applied in a mixed state, whereby the light emission of said blue light-emitting diode is wavelength-converted by said fluorescent scattering layer.

[CLAIMS]

[Claim 1] A planar light source characterized in that a blue light-emitting diode is optically connected to at least one place of an end surface of a transparent optical guiding plate, and either one of the principal surfaces of said optical guiding plate includes a fluorescent scattering layer in which a fluorescent substance emitting a fluorescence by being excited with the light emission of said blue light-emitting diode and a white powder scattering the fluorescence are applied in a mixed state, whereby the light emission of said blue light-emitting diode is wavelength-converted by said fluorescent scattering layer

and observed through a principal surface side of the optical guiding plate opposite to said fluorescent scattering layer.

[Claim 2] A planar light source as set forth in claim 1, characterized in that said blue light-emitting diode has a principal light-emission wavelength of less than 500 nm and a light emission output power of 500 □W or more.

[Detailed Description of the Invention]

[0001]

[Industrially Applicable Field] The present invention relates to a planar light source used as a back light of a display, an illuminating operation switch, or the like, and more particularly, to a planar light source capable of being suitably used as a back light of a liquid crystal display.

[0002]

[Prior Art] Generally, an EL or a cold cathode tube, for example, is used as a planar light source for a back light of a liquid crystal display to be used in a notebook type personal computer, a word processor, or the like. The EL is a planar light source in itself, and the cold cathode tube is made into a planar light source by using a scattering plate. At present, almost all of the light emission colors of these back lights are assumed to be a white color.

[0003] On the other hand, a light-emitting diode (hereafter referred to as an LED) is also used as a light source for a back light in some cases. However, in the case where a white color is to be obtained by using the LED, since the light emission output power of a blue

LED is as small as several ten □W in the prior art, in order to realize a white color light emission by using other red LED and green LED, there is a defect that it is difficult to match the characteristics of the LEDs of these colors, leading to a large color change. Also, even if the LEDs of the three primary colors are assembled and placed geometrically at the same position on the same plane, these LEDs are observed at the proximity positions as a back light, so that it was impossible to make a uniform white light source. Accordingly, currently as planar light sources of a white liquid crystal back light, a cold cathode tube is used for large sizes, while an EL is used for small to medium sizes. Almost no back light of a white color emission using an LED is known.

[0004] Also, as a white light emission light source or monochromatic light source, there is an attempt to convert the color by covering the periphery of a blue LED chip with a resin containing a fluorescent substance. However, since the periphery of the chip is exposed to light beams having a stronger radiation intensity than the solar light, deterioration of the fluorescent substance becomes a problem, and especially it is conspicuous in the case of an organic fluorescent pigment. Further, ionic organic dyes generate electrophoresis by a direct current electric field in the vicinity of the chip, leading to the possibility of color tone changes. In addition, the conventional blue LED does not have a sufficient output power for color conversion using a fluorescent substance and, even if the color conversion is carried out, it could not be put into practical use.

[0005]

[Problems to be Solved by the Invention] The present invention has been made in order to solve these problems and its purpose is to realize a planar light source capable of emitting a white color that can be used as a back light by using a LED and to provide a planar light source capable of allowing observation of a uniform white color light emission. Further, the purpose is to provide a planar light source capable of emitting an arbitrary color other than white, and to apply it for various operation switches and the like by utilizing the characteristics of the LED being excellent in reliability.

[0006]

[Means for Solving the Problems] The planar light source of the invention is characterized in that a blue LED is optically connected to at least one place of an end surface of a transparent optical guiding plate, and either one of the principal surfaces of said optical guiding plate includes a fluorescent scattering layer in which a fluorescent substance emitting a fluorescence by being excited with the light emission of said blue light-emitting diode (hereafter the principal surface on the fluorescent scattering layer side is referred to as a second principal surface) and a white powder scattering the fluorescence are applied in a mixed state, whereby a part of the light emission of said blue light-emitting diode is wavelength-converted by said fluorescent scattering layer and observed through a principal surface side of the optical guiding plate opposite to said fluorescent scattering layer (hereafter the principal surface on the light emission observing side is referred to as a first principal surface).

[0007] FIG. 1 is a plan view of an optical guiding plate 2 of the planar light source of the

invention as viewed from a fluorescent scattering layer side 3. The optical guiding plate 2 is made, for example, of a transparent material such as an acrylic resin or glass. The optical guiding plate 2 is connected to a blue LED 1 by burying and disposing the blue LED 1 in an end surface of the optical guiding plate 2. Here, in the present invention, the blue LED 1 being optically connected to the end surface of the optical guiding plate 2 refers, in short, to introduction of light of the blue LED through the end surface of the optical guiding plate 2. For example, it can be realized by bonding the blue LED or by guiding the light emission of the blue LED to the end surface of the optical guiding plate 2 using an optical fiber or the like, not to mention burying and disposing the blue LED 1 as shown in this figure.

[0008] Next, the fluorescent scattering layer 3 is made by applying an ink in which a fluorescent substance and a white pigment are blended so that a desired color can be observed. The fluorescent scattering layer 3 converts the wavelength of the light emission of the blue LED 1 by means of the fluorescent substance and at the same time, scatters the fluorescence within the optical guiding plate 2 by means of the white pigment. Especially, in FIG. 1, said fluorescent scattering layer 3 is made into dots, and made into a pattern by which the area of the fluorescent scattering layer 3 per unit area on the second principal surface side decreases so that the surface brightness of the first principal surface side becomes constant, according as it approaches the LED 1. Further, the area of the end portion of the second principal surface located at the largest distance from the LED 1 is made to be a little smaller than the maximum area. Here, the symbol

□ in FIG. 1 represents a pattern of the fluorescent scattering layer 3. FIG. 1 shows a construction in which two blue LEDs are disposed on one end surface. However, it goes without saying that LEDs can be connected to four end surfaces if the optical guiding plate is a quadrangle, and also the number of the LEDs is not limited. Furthermore, depending on the arrangement of the LEDs, the application configuration and the application state of the fluorescent scattering layer can be suitably changed so as to obtain a planarly uniform light emission as observed through the first principal surface side.

[0009]

[Action] FIG. 2 is a cross-sectional model view in the case where the planar light source of the invention is mounted, for example, as a back light of a liquid crystal panel. This includes a reflecting plate disposed on the second principal surface side of the planar light source shown in FIG. 1, the reflecting plate being a laminate of a scattering reflecting layer 6 made, for example, of barium titanate, titanium oxide, aluminum oxide, or the like and a base 7 made, for example, of Al, and includes a light scattering plate 5 disposed on the first principal surface side, the light scattering plate 5 having an uneven surface. This construction is not particularly different from the back light in which a cold cathode tube is used as the light source.

[0010] First, as shown by an arrow of FIG. 2, the light emitted from the blue LED 1 is partly radiated from a place adjacent to the chip to the outside other than the optical guiding plate, but almost all of the emitted light reaches an end surface of the optical guiding plate while repeating the total reflection in the optical guiding plate 2. The light

having reached the end surface is reflected by a reflecting film 4 formed on all the end surfaces to repeat the total reflection. At this time, a part of the light is scattered by the fluorescent scattering layer 3 disposed on the second principal surface side of the optical guiding plate 2, and a part of the light is absorbed by the fluorescent substance and at the same time, is wavelength-converted to radiate. The emission color observed through the first principal surface side of the optical guiding plate 2 is a synthesized light of these lights. For example, in a planar light source in which a fluorescent scattering layer 3 made of an orange fluorescent pigment and a white pigment is disposed, the light emission color from the blue LED can be observed as a white color by the aforementioned action. Further, the color tone can be arbitrarily adjusted by the kind of the fluorescent substance and the mixing ratio of the white pigment. Especially, the invention requires that the light emission wavelength of one blue LED has a main light emission peak shorter than 500 nm, and a light emission output power of not less than 200 □W, more preferably not less than 300 □W. This is because, if the light emission wavelength is 500 nm or more, it is difficult to realize all the colors, and if its light emission output power is smaller than 200 □W, there is a tendency that it will be difficult to obtain a light source of uniform planar light emission with sufficient brightness even if the number of blue LEDs to be optically connected to the end surface of the optical guiding plate is increased.

[0011]

[Examples]

[Example 1] A fluorescent scattering layer 3 was formed by screen printing in a dot-like pattern shown in FIG. 1 on one surface of an acrylic plate having a thickness of about 2 mm. The fluorescent scattering layer 3 was formed by printing a substance obtained by dispersing into an acrylic binder a mixture of containing a fluorescent pigment and barium titanate as a white powder at a weight ratio of 1 : 5. The fluorescent pigment had been obtained by mixing FA-001 made by Synreuch Chemical Co., Ltd. as a red fluorescent pigment and FA-005 made by the same company as a green fluorescent pigment in equal amounts.

[0012] Next, the acrylic plate having the fluorescent scattering layer formed as mentioned above is cut in accordance with a desired pattern and, after all the end surfaces (cut surfaces) of the acrylic plate are polished, reflecting layers 4 made of Al were formed on the polished surfaces to give an optical guiding plate 2 having the fluorescent scattering layer 3 formed thereon.

[0013] Holes were formed at two places on the end surface of said optical guiding plate 2, and one blue LED made of a gallium nitride compound semiconductor having a light emission wavelength of 480 nm and a light emission output power of 1200 □W was buried respectively in each of the holes to provide the planar light source of the invention. When the two blue LEDs of the planar light source were turned on at the same time, a white and almost uniform planar light emission with a yellowish color was obtained through the light emission observing side of the optical guiding plate 2. Further, a light scattering plate 5 made to mat-processing beforehand was disposed on the light emission

observing side, and a reflecting plate having a barium titanate layer 6 applied on an Al base 7 was disposed on the fluorescent scattering layer 3 side to prepare a light source for a back light, whereby a complete planarly-uniform white light emission was obtained through the light scattering plate 5 side. The brightness was 55 cd/m^2.

[0014] [Example 2] A planar light source of the invention was obtained in the same manner as in Example 1, except that the fluorescent scattering layer 3 was formed by using a mixture of a fluorescent dye and barium titanate as a white substance in a weight ratio of 1 (dye) : 200. The fluorescent dye had been obtained by mixing almost equally in weight Lumogen F Yellow-083 made by BASF Co., Ltd. as a yellow fluorescent dye and Orenge-240 made by the same company as an orange fluorescent dye, and dissolving the mixture in butylcarbitol acetate. An almost uniform planar light emission was observed. Further, a light source for a back light was prepared in a similar manner, whereby a complete planarly-uniform light emission was observed.

[0015]

[Effects of the Invention] As described above, the planar light source of the invention uses a blue LED, and includes a fluorescent scattering layer containing a fluorescent substance capable of wavelength conversion with the blue LED and a white powder on one surface of the optical guiding plate, so that the present invention has made it possible to realize a planar light source with a LED which is excellent in reliability. Furthermore, since the white powder of the fluorescent scattering layer acts to reflect and diffuse light wavelength-converted by the fluorescent substance, the amount of the fluorescent

substance to be used is reduced. A further advantage is that, since the LED chip and the fluorescent substance are not brought into direct contact, deterioration of the fluorescent substance is small and the color tone change of the planar light source is prevented for a long period of time. In addition, as to the color tone change, an arbitrary color tone including a white color can be provided by varying the kinds of the fluorescent substance and the white powder, the mixing amount, and the like.

[0016] In the meantime, a bright planar light source having a large area can be realized by conducting an effective wavelength conversion with the fluorescent substance by using most preferably a blue LED having a light emission output power of 200 □W or more for exciting the fluorescent scattering layer. As described above, the planar light source of the invention can be used not only as a light source for a back light but also as for an illuminating operation switch or the like utilizing a fluorescent substance.

[Brief Description of the Drawings]

[FIG. 1] A plan view of an optical guiding plate 2 of a planar light source of one embodiment of the present invention as viewed from a fluorescent scattering layer 3 side.

[FIG. 2] A cross-sectional model view in the case where a planar light source of one embodiment of the present invention is mounted as a back light.

[Explanation of numerals]

1 ... blue LED

2 ... optical guide plate

3 ... fluorescent scattering layer

4 ... reflecting layer

5 ... optical scattering plate

6 ... scattering reflecting layer

7 ... Al base